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ABSTRACT

This project involved the development of a manual for science teachers to use in improving their use of selected inquiry teaching behaviors. The behaviors are asking observation questions, asking interpretation questions, acknowledging and reinforcing pupil responses, extending pupil responses, and probing pupil responses. The manual, Handbook on Questioning and Using Pupil Responses in Teaching Science, was evaluated and revised through field tests with elementary teacher education students who studied the manual and practiced the teacher behaviors in science lessons taught to elementary pupils. An analysis of covariance of the results of a test on classifying teacher behaviors administered in a pretest-posttest control group design indicated that the students who participated in the main field test improved significantly in their ability to identify the behaviors. Frequency counts of the use of the teacher behaviors were made for 12 subjects, all of whom taught the same topics on two separate occasions. Analysis of the data yielded a pattern in the group's average use of the behaviors in the two lessons. The pattern can be used in establishing performance standards for teacher trainees. A 24-item bibliography and appendixes with related materials are included. (Author/MJM)

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FINAL REPORT
Project No. 1-F-058
Contract No. OEC-6-71-0543 (509)

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THE DEVELOPMENT OF AN INQUIRY TEACHING STRATEGY AND A TEACHER TRAINING MODULE FOR ELEMENTARY SCIENCE

September 1972

U.S. Department of Health, Education, and Welfare
Office of Education
National Center for Educational Research and Development
(Regional Research Program)

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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ABSTRACT

This project involved the development of a manual for teachers of science to follow in improving their use of selected inquiry teaching behaviors. The behaviors are:

(1) Asking observation questions,
(2) Asking interpretation questions,
(3) Acknowledging and reinforcing pupil responses,
(4) Extending pupil responses,
(5) Probing pupil responses.

The manual, Handbook on Questioning and Using Pupil Responses in Teaching Science, was evaluated and revised through field tests with elementary teacher education students who studied the manual and practiced the teacher behaviors in science lessons taught to elementary pupils.

An analysis of covariance of the results of a test on classifying teacher behaviors administered in a pretest-posttest control-group design indicated that the students (N = 25) who participated in the main field test improved significantly in their ability to identify the behaviors.

Frequency counts of the use of the teacher behaviors were made for 12 subjects, all of whom taught the same topics on two separate occasions. Analysis of the data yielded a pattern in the group's average use of the behaviors in the two lessons. The pattern can be used in establishing performance standards for teacher trainees.

The manual should prove especially useful in performance-based teacher education programs.

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Chapter I

INTRODUCTION AND STATEMENT OF THE PROBLEM

The purposes of this project were to identify a set of specific teacher behaviors for teaching science through an inquiry approach and to develop and test training procedures and materials for training pre-service elementary teachers in the use of these teacher behaviors.

An investigator may expect to make false starts and to experience setbacks in developing a new educational product. This project began as an effort to develop a generalized strategy for teaching science by an inquiry method. The generalized strategy was to be based on the teaching strategies developed by Hilda Taba (1967) and others for the Taba Social Studies Curriculum. The finished product of the project no longer emphasizes one strategy for all teachers but emphasizes a set of specific teacher behaviors that may be learned by teachers and that may form the basis for a variety of different inquiry teaching approaches.

The term "specific teacher behavior" refers in this project to a teacher action that is clearly definable and reliably observable and has a high likelihood of producing some specified type of pupil response.

The five teacher behaviors treated in the project are:

1.1 Teacher asks observation and description questions.
1.2 Teacher asks interpretation and explanation questions.
2.1 Teacher acknowledges and reinforces pupil responses.
2.2 Teacher extends pupil ideas.
2.3 Teacher probes pupil ideas.

Teacher behaviors 1.1 and 1.2 are intended to set the cognitive level of discussion in an inquiry lesson. Teacher behaviors 2.1, 2.2, and 2.3 are intended to be used by teachers to encourage pupil participation and to lead them to examine their own hypotheses, inferences, and suggestions in more depth. The five teacher behaviors are described in Table 1.

The primary product of this project has been a handbook designed for teacher trainees to use in developing

TABLE 1

Description of the Five Teacher Behaviors
Treated in the Project

ESTABLISHING LEVEL OF THOUGHT	1.1 TEACHER ASKS OBSERVATION AND DESCRIPTION QUESTIONS: Teacher questions designed to focus thought at a level of observation. Includes questions asking for description of objects and description of events. Emphasis is on what took place. Factual recall questions are not coded in this category. 1.2 TEACHER ASKS INTERPRETATION AND EXPLANATION QUESTIONS: Teacher questions requiring the pupil to offer tentative hypotheses, suggestions, inferences, or ideas about the reasons why an event took place; also, questions that seek patterns, relations, similarities, and differences are included.
RESPONDING TO AND USING PUPIL IDEAS	2.1 TEACHER ACKNOWLEDGES AND REINFORCES PUPIL RESPONSES: Teacher acknowledges, repeats or paraphrases, or reinforces a pupil response. 2.2 TEACHER EXTENDS PUPIL RESPONSES: The teacher extends a pupil idea by clarifying it, by comparing or contrasting it with another idea, by correcting the idea when partially or totally incorrect, and by applying the idea to problem solving; summarizing or assessing group progress is also included. As the teacher adds and uses more of his own ideas, shift from this category as he is no longer extending the ideas of pupils. 2.3 TEACHER PROBES PUPIL RESPONSES: Teacher questions asking pupils to follow through on their own ideas, includes seeking clarification or justification of ideas by the pupils; seeking verification of pupil hypotheses; and building a question based on the idea of a pupil. Code a question in this category only if it is used by the teacher to follow up on ideas expressed by pupils.

proficiency with the five teacher behaviors. The handbook and the teacher training procedures outlined in it evolved through two trial editions and field testing over two semesters with approximately 100 undergraduate elementary education majors and 250 fourth-, fifth-, and sixth-grade pupils.

Chapter II

RELATED RESEARCH

It is generally acknowledged that teacher behaviors chosen for emphasis in performance-based teacher education (PBTE) programs should be those that have been closely investigated by researchers and for which some correlation with measures of pupil growth have been found. Unfortunately, the current research base is much too inadequate to support complete PBTE programs. There are scattered areas in which research foundations, although very shaky, are being developed. Fortunately, there is some research evidence to support the selection of the five teacher behaviors of this project as a part of the PBTE program.

Research on Teacher Questioning

There currently exist a large number of systems for use in observing and describing events that take place in the classroom. The primary data obtained through using the classroom observation systems are relative frequencies of occurrence of defined types of teacher and pupil behavior. An important line of research involving the observation systems has been to attempt to identify effective teacher behaviors by examining correlations of frequencies of given teacher behaviors and measures of pupil achievement or pupil attitudes.

One of the most widely used of the classroom observation systems is the Flanders' Interaction Analysis Categories (FIAC) system. The Flanders' system contains a category of teacher talk related to asking questions (category 4 of ten categories). Any teacher question about content or procedures, that is based on teacher ideas and is intended for pupils to answer, is classified in this category.

Flanders (1970) has summarized the results of several years of teacher behavior research in which the FIAC system was used. In seven studies at five grade levels, Flanders (1970, pp. 393-396) reports that the relative frequency of teacher questions correlates relatively highly with pupil achievement in only one of the five grade levels (grade eight) and with pupil attitude at two of the five grades

(second and eighth). No general pattern on teacher questioning seemed to emerge from these studies.

In a very useful review of research on teacher behavior and pupil achievement, Rosenshine (1971, pp. 80-81) located studies by five different researchers which do tend to show a positive relationship between frequency of questioning and pupil achievement. Rosenshine believes that these results tend to suggest that, at least in the primary grades, frequent questioning is a part of effective teaching.

In developing teacher education programs, educators also need information on the effects of different types of questions on pupils. Rosenshine (1971) classified the several types of teacher questions into two forms, labeled "lower cognitive level" and "higher cognitive level" questions. The lower cognitive level questions generally focused on "what" or "where" and the higher level questions on "why" and "how." In the analysis of seven studies, Rosenshine (1971) concludes that there are no consistent significant results relating the frequency of either the higher or lower level questions teachers ask and pupil achievement.

Rosenshine (1971) cites four investigators who have studied the possibility of a non-linear relationship between types of questions and pupil achievement. He suggests on the basis of these four studies that moderation and/or variation in the use of questions of various types is important.

In most of the studies reviewed by Flanders (1970) and Rosenshine (1971), teacher questions are merely counted. No attempt seems to be made in coding lessons to distinguish between high and low quality questions. All questions are treated alike. One question worded in the right way and coming at the right time, however, could be sufficient to stimulate considerable pupil thought and growth. There is a need for future investigations which consider not only frequency of question types but also the quality of the questions, as defined, perhaps, in terms of wording and timing.

Teachers usually are interested in leading pupils to engage in thought at specified cognitive levels, for example, levels of observation, interpretation, application, evaluation, and so on. Both Flanders (1970) and Gallagher (1970) note that there is a close relationship between the type of teacher questions asked and the nature of thought expressed by pupils. This finding is, perhaps, intuitively obvious but still very important. If teachers desire certain types and levels of thinking from pupils, they

need to know how to ask questions that elicit the particular type of thinking desired.

Taba (1966) has developed a teaching strategy which is intended to help pupils develop thinking skills. Three cognitive levels are emphasized in the teaching strategy: concept development, inferring and generalizing, and applying generalizations. In connection with the development of the Taba Social Studies Curriculum, a group of elementary teachers were trained to sequence questions so that higher level cognitive tasks (generalization and application) were built on lower level tasks (concept development). One finding of Taba was that unless sufficient discussion time is spent in developing an adequate foundation at the lower cognitive level, pupils are not able to sustain discussion at the higher levels of thought (Taba and Elzey, 1964).

In summary, there appears to be a positive relationship between the number of questions a teacher asks and pupil achievement. However, no evidence of a linear relationship between the frequency of different types of teacher questions and pupil achievement has been found. Some studies indicate that moderation and/or variation in the type of question asked is important. One finding that is, perhaps, intuitive but very important is that the cognitive level of pupil thought is dependent upon the level of teacher questions. Taba's work support this finding but adds the further results that unless teachers restrain pupils from moving too quickly from lower to higher levels of thought, discussion at the higher levels can not be sustained.

All of the reviewers emphasize that the results are very tentative and much further research is needed.

Research on Accepting and Using Pupil Ideas

Category 3 in Flanders' Interaction Analysis Categories system is concerned with teacher acceptance or use of pupil ideas. The category includes teacher statements which clarify or develop ideas suggested by pupils and questions which teachers use to encourage pupils to look in more depth at their own ideas.

Research related to this category of teacher behaviors has been quite fruitful. The importance of teachers accepting and using the ideas of their pupils seems to be one of the most firmly established results of teacher effectiveness research. Flanders and Simon (1969), after reviewing several studies, concluded that there is a direct relation between the relative frequency of teacher statements that make use of ideas and opinions expressed previously by

pupils and pupil scores on both attitude and achievement measures.

Rosenshine (1971) comes to a similar but less enthusiastic conclusion. He concludes that we have some research support for the positive effects of the teacher's use of pupil ideas, but he feels that it is not as strong or as clear as we might like.

Nuthall (1970), in still another review of teacher effectiveness research, concluded that pupil growth seems to depend, among other things, on the teacher's ability to stimulate pupil participation in discussion and to involve pupils in the development and extension of ideas.

Several investigators have looked at the teacher's use of questions which attempt to lead pupils toward more comprehensive responses than their initial answers. This teacher behavior has been given the label "probing." Probing may be considered as a subcategory of Flanders' category 3 on accepting and using pupil ideas. Rosenshine (1971) cites at least two studies which show that the use of probing questions is a significant correlate with pupil achievement.

The majority of the evidence at present points to the importance of teachers being able to elicit ideas from pupils and then being able to encourage use of these ideas in the ensuing discussion. The significant thing seems to be to require pupils to think more deeply about their initial, superficial responses. Although there is much research still to be done in this area, there is a rather firm foundation on which to construct teacher training materials.

In the present project, the decision was made to subdivide Flanders' category 3 on accepting and using pupil ideas and to train teacher candidates in the use of the subcategories. This decision was based on a suggestion by Flanders (1970, p. 134). He suggested that his category 3, teacher accepts and uses pupil ideas, may yield more useful information in certain types of studies if it were subscripted as follows:

Category 3.1:	Merely acknowledges or repeats pupil ideas.
Category 3.2:	Makes use of a pupil idea by clarifying it, making comparisons, or applying it to problem-solving steps.
Category 3.3:	Like 3.2, except it is in the form of a question with the intent that a pupil answer.

The reader may wish to compare the categories on using pupil ideas as treated in the project (Table 1, categories 2.1, 2.2, and 2.3) with those suggested by Flanders.

Chapter III

PROCEDURES AND RESULTS IN PRODUCT DEVELOPMENT

The main product of this project has been a handbook presenting procedures for teachers or teacher candidates to follow in developing competence with the set of five specific teaching behaviors. The handbook is entitled Handbook on Questioning and Using Pupil Responses in Teaching Science. The handbook and teacher training system were evaluated through a preliminary field test in the Fall of 1971 and a main field test in the Spring of 1972.

Preliminary Field Test

The first trial edition of the teacher trainee handbook emphasized an inquiry teaching strategy based on the inductive teaching strategy developed by Hilda Taba (1967) for social studies teaching. The inquiry strategy revolved around a set of model questions designed to focus pupil attention on the following inquiry tasks in science: (1) exploring problem situations, (2) observing and describing, (3) interpreting data of observation, (4) applying generalizations. It was intended that the model questions be used in a designated sequence.

In the Fall of 1971 a preliminary field test designed to determine the general usability and success of the inquiry strategy and handbook were conducted. Twenty-three senior elementary education majors taught by the author in a science teaching methods course were involved in all phases of the evaluation. In addition, approximately forty other students read and reacted to the handbook.

After participating in several inquiry sessions conducted by the author, the participants were given copies of the inquiry teaching strategies handbook. The handbook was discussed in one class period and then studied individually by the participants.

The participants, in teams of two (three in one case), prepared and taught a 2-day sequence of lessons on topics of simple electricity to groups of 4-6 fourth-grade pupils. Audio tape recordings were made of each session. Each participant listened to his or her own tape, made a tape-script of a portion of it, and coded and analyzed the

tapescript using an inquiry teaching analysis system developed in the project and explained in the handbook. Each subject also responded to a 15-item self-rating form.

After analysis and group discussion of the first set of lessons, the twenty-three participants prepared and taught a second 2-day sequence of lessons involving concepts of air pressure to groups of 4-6 sixth-grade pupils. For this lesson, participants were instructed to use ideas submitted by pupils as much as possible, a teacher behavior exhibited only rarely in the first lesson. The lessons were taperecorded and participants wrote out and analyzed tapescripts for four selected topics common to all the lessons.

On the basis of the feedback from the preliminary field test, the teacher's handbook for inquiry teaching was extensively rewritten. In the revised edition, a major shift of emphasis was made. Rather than emphasizing a single inquiry teaching strategy, the revised manual emphasized five teacher behaviors (Table 1) that are intended to be put together by the individual teacher into an inquiry teacher strategy of his or her own design. In addition, the inquiry teaching self-analysis system was completely revised. The self-rating form was discarded and replaced by a series of questions requiring the teacher to describe, analyze, and evaluate his or her own inquiry teaching behavior.

The revised handbook and coding, analysis, and rating system were evaluated in the main field test in the Spring of 1972.

Main Field Test

The main field test of the revised handbook and the teacher training procedures and coding instructions presented in it took place in the Spring of 1972. Twenty-five senior elementary education majors were involved as the experimental group in the field test.

The goals of the main field test were as follows:

1. to determine if there was any change during the field test in the experimental group's ability to categorize teacher statements and questions using a category system composed of the five specific teacher behaviors described in the handbook;

2. to determine if the coding instructions and procedures were sufficiently clear so that

consistent results could be obtained using them;

3. to describe the experimental group's use (through frequency counts) of the five specific teaching behaviors in teaching science lessons to elementary pupils, in an attempt to gather tentative normative data; and

4. to identify weak points in the handbook, teacher training procedures, and coding instructions and procedures in order that needed revisions could be made.

Changes in ability to categorize teacher questions and statements. Data for determining if the experimental group improved in ability to categorize teacher questions and statements using the five specific teaching behaviors was collected through the use of a 35-item test called the Classification of Teacher Behaviors Test (Appendix A). The test consists of teacher statements and questions placed in the context of parts of science lessons. Participants were given descriptions of the five teacher behaviors and instructed to assign each teacher statement or question where possible to one of the five categories. It is assumed that significant change in the experimental group's ability to recognize the five teacher behaviors would be one indication of the success of the handbook.

A pretest-posttest control-group design was used in testing the hypothesis that there is no significant change in the experimental group's scores on the Classification of Teacher Behaviors Test. The control group consisted of 30 students in a second science methods course taught by the author and 22 students in a science methods course taught by another professor. None of the control group subjects was exposed to the experimental materials or methods.

The means and standard deviations of the scores of the experimental and control groups on the pretest and posttest are given in Table 2.

The results of an analysis of covariance (Kirk, 1968) done on the scores on the Classification of Teacher Behaviors Test are reported in Table 3. In the analysis of covariance, the posttest means are compared using the pretest means as the covariate (Borg and Gall, 1971). The results indicate that there is a significant change, and we may infer that the experimental group did improve in ability to categorize teacher questions and statements using the teacher behavior categories described in the handbook.

TABLE 2

Means and Standard Deviations on the Classification of Teacher Behaviors Test

	N	Pretest $\bar{X}$	Pretest s	Posttest $\bar{X}$	Posttest s
Group I (Exp.)	25	22.76	4.07	23.84	2.83
Group II (Control)	30	23.33	3.88	22.63	5.04
Group III (Control)	22	22.55	.78	21.95	3.31

TABLE 3

Analysis of Covariance Table for Comparison of Posttest Means on the Classification of Teacher Behaviors Test Using the Pretest Means as the Covariate

Source	SS	df	MS	F
Between Groups	320.8	2	160.4	145.8*
Within Groups	81.9	73	1.1	
Total	402.7	75		

*Significant at .01 level

In addition to the statistical test, an item analysis of the posttest results of the experimental group was carried out. Several changes in the descriptions of the teacher behaviors and the coding ground rules presented in the handbook were made on the basis of this analysis, in an effort to improve the teacher behavior coding procedures.

Consistency of coding. An effort has been made in the project to make the descriptions of the categories, the coding instructions and the ground rules sufficiently clear so that potential users of the category system can agree on the assignment of teacher statements to categories. In an attempt to improve the coding instructions and procedures, the principal investigator and a graduate student research assistant independently coded the tapes of several lessons taught by the experimental subjects. An event-by-event comparison was then made on all of the coded teacher

statements. When disagreements could not be resolved through reference to written procedures, appropriate revisions were made in the description of the teacher behavior categories, the coding instructions, or the coding ground rules.

The interrater reliability between the principal investigator and the research assistant was determined through use of the Scott coefficient described by Flanders (1965). The Scott coefficient is a measure of the extent to which two observers agree in the assignment of teacher behaviors to categories. The median value of the Scott coefficient obtained through comparison of the data on eight lessons coded by the principal investigator and the research assistant was .69 with a high of .79 and a low of .48. These values should be considered to be low estimates of the degree of interrater reliability to be expected since the coding procedures of the category system were revised on the basis of the comparisons.

In one phase of the present study the experimental subjects coded their own teaching behaviors from audio tape recordings of science lessons which they had taught to small groups of children. The primary purposes of this coding were to attempt to make the teacher trainees more aware of their own teaching behavior and to induce them to make needed adjustments in teaching. The Scott coefficient (Flanders, 1965) was again used to determine the interrater reliability between each experimental subject coding his or her own taped lesson (before final revision of the coding system) and the coding of the tape by the principal investigator (after revision of the coding system procedures). Interrater reliabilities obtained in this way were generally low, ranging from about .20 to about .70 with a median of approximately .50.

The minimum degree of consistency that is acceptable between coders using a category system depends upon the purposes of the coding and the uses of the data. When the data is used in studies attempting to correlate frequencies of given teaching behaviors with pupil outcome variables, high interrater reliabilities are necessary. In such studies raters undergo training for as long as 15 hours until interrater reliabilities are sufficiently high.

Data obtained through coding procedures was used in the present study to help the teacher trainees to be more aware of their own teaching behavior and to make needed improvements in teaching. In the author's judgment, lower interrater reliabilities may be defended in this case. What is required is that raters be able to agree on major exemplars of the defined teaching behaviors. Disagreement on lesser exemplars will lower reliability coefficients

but should not interfere extensively with judgments on needed improvements in the use of the teaching behaviors.

Normative data on the use of the teacher behaviors. The usefulness of the handbook and teacher training procedures would be considerably enhanced if teacher trainers had available some normative data on the use of the five teacher behaviors. For instance, such data could be used in establishing performance standards for teacher candidates.

Following procedures similar to those used in the preliminary field test, the 25 experimental subjects studied the handbook on the five teacher behaviors and then prepared and taught a 2-day sequence of lessons involving the concept of air pressure to groups of 4-6 fifth-grade pupils. The lessons were tape recorded and later coded and analyzed by the participants. Three 1-hour class periods were devoted to coding and analysis with the principal investigator available to the participants for assistance as needed.

Two weeks after the first teaching, a 1-day lesson on the same topics was taught in the same small-group teaching format to another group of fifth graders. These lessons were again tape recorded, coded, and analyzed by the participants.

Data on the frequency of occurrences of each teacher behavior during the first lesson and the second lesson are given in Table 4. These frequencies represent the coding of the principal investigator. Due to various difficulties usable first and second teaching tapes were available for only twelve participants.

Although all lessons centered around a common group of air pressure problems drawn from the Elementary Science Study Unit on Gases and "Airs" (ESS, 1967), the lessons were not standardized in terms of objectives, procedures, sequence of activities, or time. For comparison purposes, the Table 4 frequencies of the defined teacher behaviors were adjusted to 15-minute lessons. The adjusted data is presented in Table 5.

Examination of the data from individual teachers does not seem to reveal any pattern or trend. However, a comparison of the data from any one individual with that of the whole group can be useful in detecting extremes in the use of one or more of the teacher behaviors. For example, on both lesson one and lesson two, Jank's total use of the five behaviors is the lowest of the group. As a second example, it can be seen that Janh, Sha, and Tru consistently used the technique of probing (category

2.3) more often than most of the other members of the group. An examination of the data also shows that Fra's use of techniques of acknowledging and reinforcing pupil responses (category 2.1) is consistently high while Jank's use of this teacher behavior is consistently low. Whether Fra uses this teacher behavior too much or Jank uses it too little is a matter for the teacher trainee and the instructor to consider together.

Means and medians of the use of the teacher behaviors by the trainees in 15-minute lessons are given in Table 6. Graphs of the means and medians are shown in Figure 1 and Figure 2. The graphs show that there are only small differences in the patterns of use of the teacher behaviors between lesson one and lesson two. Although the number of subjects is small (12) and the data have been adjusted from lessons of varying lengths to 15-minute lessons, the procedures show promise of eventually providing us with normative data on the use of defined teaching behaviors in specified types of lessons.

TABLE 4

Frequency of Use of Each Teacher Behavior by Teacher Trainees During Two Fifth-Grade Lessons on Air Pressures

Lesson One

Behavior	Teacher											
	Vic	Sha	Jank	Nan	Car	Mar	Janh	Rob	Tru	Lin	Fra	Bar
1.1 Observ. Quest.	7	3	3	0	9	1	4	7	4	7	9	3
1.2 Interp. Quest.	9	12	4	9	11	8	7	6	16	15	8	11
2.1 Ackn. and Reinf.	11	8	5	5	14	4	10	7	16	15	19	13
2.2 Extending	18	4	3	4	8	11	8	9	11	3	9	11
2.3 Probing	8	7	2	3	13	5	19	9	13	3	7	3
Time of lesson in minutes	26.8	13.6	15.0	8.9	20.6	16.0	25.0	20.0	18.7	13.5	15.3	14.5

Lesson Two

Behavior	Teacher											
	Vic	Sha	Jank	Nan	Car	Mar	Janh	Rob	Tru	Lin	Fra	Bar
1.1 Observ. Quest.	5	2	0	4	4	2	6	5	14	9	4	3
1.2 Interp. Quest.	9	1	4	6	12	10	16	9	12	13	6	8
2.1 Ackn. and Reinf.	9	4	4	8	18	10	14	10	17	9	10	12
2.2 Extending	12	9	4	5	5	7	13	7	8	8	4	6
2.3 Probing	4	8	0	3	3	13	19	16	22	4	2	11
Time of lesson in minutes	17.0	12.8	16.4	17.2	12.0	16.0	26.0	20.0	21.5	13.6	7.5	11.9

TABLE 5

Frequency of Use of Each Teacher Behavior During
Lessons on Air Pressure, Adjusted
to Fifteen-Minute Lessons

Lesson One

Behavior	Teacher											
	Vic	Sha	Jank	Nan	Car	Mar	Janh	Rob	Tru	Lin	Fra	Bar
1.1 Observ. Quest.	4	3	3	0	6	1	2	5	3	8	9	3
1.2 Interp. Quest.	5	13	4	15	8	8	4	5	13	17	8	11
2.1 Ackn. and Reinf.	6	9	5	8	10	4	6	5	13	17	19	13
2.2 Extending	10	4	3	7	6	10	5	7	9	3	9	11
2.3 Probing	4	8	2	5	9	5	11	7	10	3	7	3

Lesson Two

Behavior	Teacher											
	Vic	Sha	Jank	Nan	Car	Mar	Janh	Rob	Tru	Lin	Fra	Bar
1.1 Observ. Quest.	4	2	0	3	5	4	3	4	10	10	8	4
1.2 Interp. Quest.	8	1	4	5	15	9	9	7	8	14	12	10
2.1 Ackn. and Reinf.	8	5	4	7	23	9	8	8	12	10	20	15
2.2 Extending	11	11	4	4	6	7	8	5	6	9	8	8
2.3 Probing	4	9	0	3	4	12	11	12	15	4	4	14

TABLE 6

Means and Medians of the Frequency of Use of Defined Teaching Behaviors During Fifteen-Minute Lessons

N = 12

Behavior	Means		Medians	
	Lesson One	Lesson Two	Lesson One	Lesson Two
1.1 Observ. Quest.	3.9	4.8	3.3	4.0
1.2 Interp. Quest.	9.3	8.5	8.2	8.5
2.1 Ackn. and Reinf.	9.6	10.7	8.5	8.5
2.2 Extending	7.0	7.3	7.0	7.5
2.3 Probing	6.0	7.7	7.0	6.5

FIGURE 1

Graph of Mean Frequency of Use of Defined Teaching Behaviors in Fifteen-Minute Lessons

N = 12

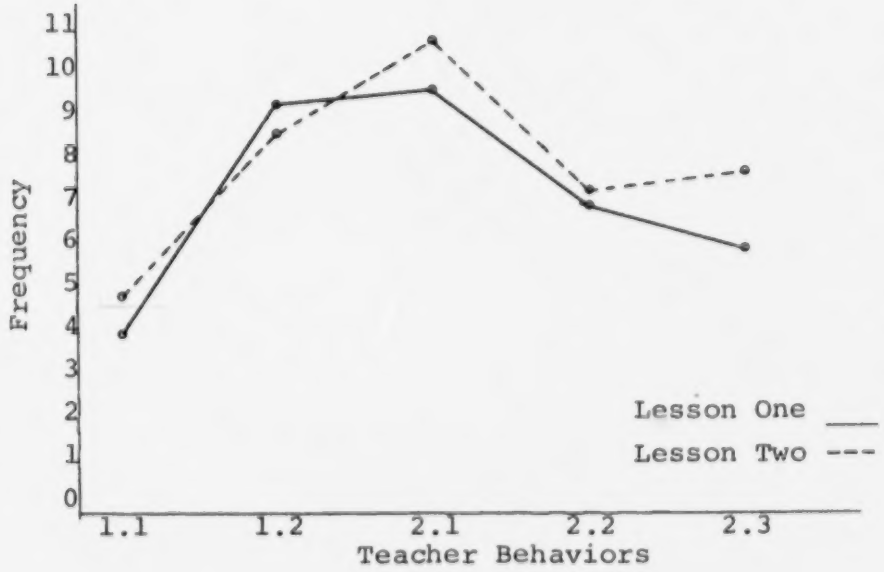
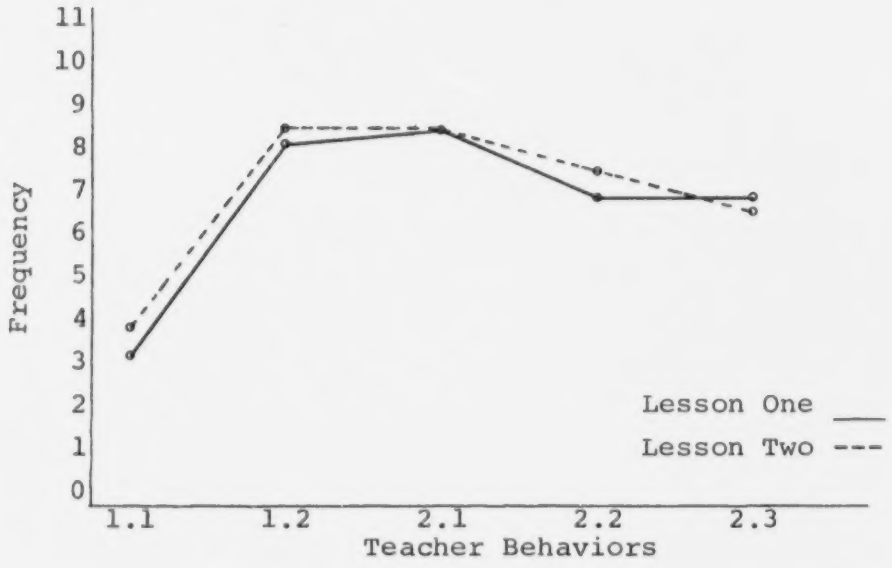


FIGURE 2

Graph of Median Frequency of Use of Defined Teaching Behaviors in Fifteen-Minute Lessons

N = 12



Chapter IV

DESCRIPTION OF THE PRODUCT

The main product of the project has been a teacher handbook entitled Handbook on Questioning and Using Pupil Responses in Teaching Science. In this section is given an overall narrative description of the handbook, its uses, its aims, and a specific statement of the objectives teacher trainees are expected to achieve through studying the handbook and following the suggested training procedures. For specific details, the reader is referred to the handbook, which is included as Appendix B of this report.

The handbook is intended to be used by teachers in learning to use a set of specific skills in teaching science through an inquiry approach. The handbook was written primarily for use by pre-service elementary teachers in an undergraduate course on the methods of science teaching. The techniques described in the handbook have been tested by pre-service teachers with fourth-, fifth-, and sixth-grade pupils. The handbook should also prove useful with in-service teachers and in methods courses for secondary teachers of science.

The Handbook on Questioning and Using Pupil Responses in Science Teaching consists of four chapters. Chapter One introduces the five specific teacher behaviors (see Table 1) and discusses the rationale for their use in inquiry teaching.

The five specific teacher behaviors for inquiry teaching are described in detail in Chapters Two and Three in the handbook. The first two teacher behaviors are intended to set the cognitive level of discussion in an inquiry lesson. The teacher behavior "teacher asks observation and description questions" is used to elicit descriptive information about a problem event from pupils. The teacher behavior "teacher asks interpretation and explanation questions" is used to encourage pupils to offer tentative hypotheses, suggestions, inferences, and ideas about why the event took place. A number of question types for these two teacher behaviors and suggestions on tested questioning techniques are included in Chapter Two.

Chapter Three describes three categories of teacher behaviors for teachers to use in responding to and using pupil ideas. Many examples of each of the three teacher behaviors are presented in the chapter. The first category, "acknowledging and reinforcing pupil responses," serves to give some recognition to pupils for their ideas and to encourage pupils to participate in the discussion.

Through the teacher behavior labeled "extending pupil responses" the teacher clarifies vague or unclear contributions by pupils, clears up misconceptions, adds useful information to the discussion, and gives directions to the discussion.

"Probing pupil responses" is the teacher behavior a teacher selects when he wishes to encourage pupils to look in more depth at their own ideas.

Chapter Four in the handbook presents procedures for the teacher to follow in developing performance capabilities with the five defined teaching behaviors. A sequence of planning, practice, analysis, evaluation, and more practice is given.

First, the teacher trainee plans a lesson to teach to a small group of pupils. Second, the lesson is taught in a controlled micro-teaching type situation with the teacher attempting to use each of the five teaching behaviors several times.

The lesson is recorded on audio tape and in step three the taped lesson is analyzed using a special inquiry teaching coding system. In brief, an observer using the coding system listens to the taperecording of a lesson and tallies or notes the occurrence of each of the five specific teacher behaviors defined in the handbook. A set of ground rules for the observer to follow in coding a lesson is included in the chapter, as well as a very specific description of each of the five categories of teacher behaviors.

The tallying of the teacher behaviors on the coding form is intended to provide objective data about teaching performance. In step four the objective data is used as a partial basis for making subjective judgments about the quality of the use of the teaching behaviors. This step involves the answering of a set of eight questions by each teacher trainee about his or her teaching performance.

Each chapter in the handbook includes a set of instructional objectives detailing what is expected from the learner in demonstrating knowledge and performance level capabilities. The performance level objectives of

Chapter Four require the teacher trainee to demonstrate in a lesson taught to school pupils that he or she can use each of the five specific teacher behaviors at a specified level of performance. The most important objectives that teacher trainees are expected to achieve through studying the handbook are given below.

A teacher trainee who has successfully completed the handbook and training procedures should be able to:

1. discuss the meaning and use of each of the following five teacher behaviors and both give and identify several examples of each:

   1.1 Teacher asks description questions
   1.2 Teacher asks interpretation questions
   2.1 Teacher acknowledges and reinforces pupil ideas
   2.2 Teacher extends pupil ideas
   2.3 Teacher probes pupil ideas

*2. code a taped inquiry lesson using the Inquiry Teaching Coding Form and the ground rules for coding, getting at least 60%-70% agreement with another coder on the assignment of behavioral events to specific categories;

*3. teach a 15-minute inquiry lesson using each of the five defined teaching behaviors at least six times with at least three of the behaviors in each category being clearly of high quality relative to wording, timing, and effect on pupils as judged by an outside observer.

*The minimum percentage of agreement in objective 2 and the minimum number of total occurrences and high quality occurrences given in objective 3 represent reasonable expectations of pre-service teachers as judged from the analysis of data collected in field testing. A given course instructor may wish to establish different performance standards for these objectives.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

This project sought to identify a set of specific teacher behaviors for teaching science through an inquiry teaching approach and to develop and test procedures for training pre-service elementary teachers in the use of the teacher behaviors. The five teacher behaviors identified were:

1.1 Asking observation and description questions.
1.2 Asking interpretation and explanation questions.
2.1 Acknowledging and reinforcing pupil responses.
2.2 Extending pupil responses.
2.3 Probing pupil responses.

There have been several research investigations that suggested that these particular teacher behaviors are important for the teacher to know and to use. Several investigators have noted that the cognitive level of responses by pupils is highly dependent upon the cognitive level of the teacher's questions. In keeping with this finding, teacher behaviors 1.1 and 1.2 are intended to be used by the teacher to set the cognitive level of discussion in a lesson.

Investigators have also noted a positive correlation between teacher acceptance and use of pupil ideas and pupil achievement. Teacher behaviors 2.1, 2.2, and 2.3 represent ways teachers can acknowledge, reinforce, clarify and elaborate on pupil ideas and ways teachers can probe to get pupils to examine their own ideas in more depth.

A booklet entitled Handbook on Questioning and Using Pupil Responses in Teaching Science was developed in the project. The handbook should prove useful in pre-service teacher education programs in the training of prospective teachers to use the five teacher behaviors. The training procedures outlined in the handbook involve the teaching and analysis of audio-tape-recorded lessons taught in a modified micro-teaching format.

The handbook and teacher training procedures were tested over a two-semester time period. Approximately

100 elementary teacher education students and 250 fourth-, fifth-, and sixth-grade pupils were involved in the various phases of the evaluation.

The preliminary field test in the Fall of 1971 was used primarily for a formative evaluation of the product. The handbook and the training procedures were substantially revised on the basis of this try out.

The main field test in the Spring of 1972 was intended to provide some information on the success of the handbook and to identify parts of the handbook and teacher training procedures that might need further revision.

One task of the main field test was to gain some indication of the effects of studying the handbook and participating in the teacher training procedures on the ability of teacher candidates to recognize and identify instances of the five teacher behaviors. To meet this task, a test called the Classification of Teacher Behaviors Test was developed. A pretest-posttest control-group design was used to determine if the experimental group experienced a change in their ability to recognize the five teacher behaviors in the context of lessons. Analysis of covariance results (Table 3) indicated that there was a significant change. We may infer that the experimental group did improve in ability to categorize teacher questions and statements using the teacher behavior categories described in the handbook.

An item analysis of the posttest results of the experimental group on the Classification of Teacher Behaviors Test yielded information on specific difficulties the teacher trainees were having in identifying the defined teacher behaviors. On the basis of this analysis, further revisions were made in the descriptions of the teacher behaviors, the coding procedures, and the ground rules for coding.

A second task of the main field test was to gain some indication of the consistency to be expected among different individuals using the coding system. After some revising of the coding system, the principal investigator and a research assistant were able to achieve a fair degree of consistency when coding taped lessons. The degree of consistency between teacher trainees and the principal investigator coding a taped lesson was generally low.

The primary purpose of the coding of lessons by the teacher trainees is to make them more aware of their own teaching behavior and to induce them to make needed adjustments in teaching. Low overall reliability coefficients may be defended if the teacher trainees are able to agree

on major exemplars of the defined teacher behaviors. Disagreement on lesson exemplars will lower the consistency of coding results but should not greatly affect judgments on needed teaching improvements.

If in further studies higher interrater reliability coefficients are required, either teacher candidates should receive considerably more training in coding or trained outside coders should be used.

A third task of the main field test was to gather data on the experimental group's use of the five defined teacher behaviors in teaching science lessons to elementary pupils. The raw data is presented in Table 4. For comparison purposes all data was adjusted to 15-minute lessons. Frequencies of teacher trainees' use of the five defined teacher behaviors, adjusted to 15-minute lessons, are given in Table 5. The data in Table 5 represents a start toward obtaining normative data on pre-service teachers use of the teacher behaviors. Such normative data should prove extremely useful in setting performance standards for teacher trainees in performance-based teacher education programs.

On the basis of the main field test, several portions of the handbook were revised. The revised edition of the handbook is included with this report as Appendix B.

Recommendations for Further Research and Development

Several lines of further research and development are suggested by the successes and failures of this project. Three possible projects will be mentioned. First, the procedures for training teachers to use the five teacher behaviors need further refinement and improvement. It is suggested that audio and visual materials that show qualified teachers using the five behaviors be developed. Such materials could provide the teacher trainees with models that they could attempt to imitate in their initial efforts at using the teacher behaviors. The development of simulation games and other learning exercises that require teacher trainees to recognize and use the teacher behaviors, perhaps in interaction with their peers, should also prove beneficial.

This project represents an example of the translation of research on the effectiveness of a given group of teacher behaviors into usable tools for teacher training. As a second line of research-based development, it is suggested that similar teacher training tools be developed for other teacher behaviors. For example, materials and procedures might be developed for the following teacher behaviors:

a. Informing: teacher gives factual or theoretical information to pupils.

b. Structuring: teacher structures discussion so as to cue pupils on what is expected from them.

c. Explaining: teacher statements, usually oral and extemperaneous, that attempt to engender comprehension of some process, concept, or generalization.

The third line of research would involve the development of "evaluative teaching units." Flanders (1970) has suggested a coordinated effort among many researchers to develop and standardize "evaluative teaching units" that can be used in judging the effectiveness of the teaching behavior of teacher trainees. Such a unit would contain a teacher's manual outlining objectives and learning activities for students, instructional materials that fit a wide range of teaching styles, standardized instructions that help to control class time allocated to the unit and other variables, carefully defined tests for pre- and post-assessment of student achievement and attitudes, and some basic category system for use in objectively describing teacher behavior. Evaluative teaching units could be for teacher training what standardized tests have been for classroom teaching. They could furnish an objective basis for comparing the teaching behavior of different individuals, for identifying strengths and weaknesses in an individual's teaching style, and for judging more and less effective training programs for teachers. The materials used and developed in the present project could well serve as the basis for an evaluative unit on inquiry teaching in science.

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APPENDICES

APPENDIX A

CLASSIFICATION OF TEACHER BEHAVIORS TEST

Classification of Teacher Behaviors Test

Below is a list of categories of teacher behavior. On the following pages you will find a series of teacher statements and questions set in the context of a science lesson. Identify which of the categories each question or statement by the teacher fits into by writing the number of the category in the space provided at the left of the question or statement. If a teacher question or statement does not correspond to any of the given categories, leave the space blank.

CATEGORIES OF TEACHER BEHAVIOR

1. FOCUSING ON OBSERVATION AND DESCRIPTION: Teacher questions designed to focus thought on "what" is given. Includes questions asking for description of objects and description of events.

2. FOCUSING ON INTERPRETATION AND EXPLANATION: Teacher questions requiring the pupils to offer tentative hypotheses, suggestions, inferences, or ideas about "why" an event took place. Questions that seek patterns, relations, similarities, or differences are included.

3. ACKNOWLEDGING AND REINFORCING PUPIL RESPONSES: The teacher acknowledges, repeats or paraphrases, or reinforces a pupil response.

4. EXTENDING PUPIL RESPONSES: The teacher extends a pupil idea by clarifying it, by comparing or contrasting it with another idea, by correcting the idea when partially or totally incorrect, or by applying the idea to problem solving. Summarizing and assessing group progress is also included. As the teacher adds more of his own ideas, shift from this category, as he is no longer extending pupil ideas.

5. PROBING PUPIL RESPONSES: Teacher seeks clarification or justification of ideas by the pupil; teacher prompts pupil with hints; teacher seeks verification of pupil hypotheses; or teacher builds a question based on the idea of a pupil.

_____ 1. Teacher: Why do you suppose that astronauts weigh less on the moon than on the earth?
Pupil: I don't know . . .

_____ 2. Teacher: Not only do the astronauts weigh less, they can jump higher. Why?
Pupil: Gravity?

_____ 3. Teacher: What about gravity?
Pupil: The astronauts would weigh less because there is less gravity on the moon.

_____ 4. Teacher: Good!

****

_____ 5. Teacher: What were some of the things you noticed in the film, John?
John: What was the question?

_____ 6. Teacher: Pay closer attention.

_____ 7. Teacher: What were some of the things you noticed in the film?
John: One ice cube floated and the other one sank.

_____ 8. Teacher: O.K.

_____ 9. Teacher: Can you add anything else, Bobby?

****

Mary: I think that the glass on the right is not water.
_____ 10. Teacher: Alright. That's one possibility.

_____ 11. Teacher: Mary, tell us how you arrived at the conclusion that it is not water.

****

_____ 12. Teacher: How far is it to the Sun?
Pupil: Ninety-three million miles.

_____ 13. Teacher: Ninety-three million miles.

****

_____ 14. Teacher: Tell us how you wired your circuit to make the bulb light.
Pupil: Circuit?

_____ 15. Teacher: What did you do to make the bulb light?
Pupil: I put a wire from this end of the battery to here, and I put a wire from the other end of the battery to the bottom of the bulb.

_____ 16. Teacher: One wire on the side of the bulb and one wire on the bottom.

****

_____ 17. Teacher: How are chimpanzees and gorillas alike?
Pupil: Chimpanzees and gorillas both travel in groups.

_____ 18. Teacher: That's a good point.
Pupil: Gorillas are much larger than chimpanzees and both live in trees.

_____ 19. Teacher: Yes, gorillas are larger. But, gorillas do not stay in trees nearly as much as chimpanzees do.

****

_____ 20. Teacher: Have you found any relationships between the length of the pendulum and the rate?
Pupil: The longer the pendulum, the slower it swings.

_____ 21. Teacher: And what about the relationship between the weight and the rate?
Pupil: Changing the weight doesn't change the rate.

****

_____ 22. Teacher: Why do you think that air expands when it gets hot?
Pupil: Because of the molecules . . . they go fast.

_____ 23. Teacher: The molecules move faster and faster and tend to get further and further apart.

_____ 24. Teacher: Now let me summarize what you have said. John said that heat made the pressure increase, and that is right. Mary said the heat made the air expand and that is also right. When you heat a gas, the pressure tends to go up and the gas tends to expand.

_____ 25. Teacher: Alright, John, tell me what you think would happen if I blew up this balloon and put it in the refrigerator.
John: The molecules would contract.

_____ 26. Teacher: Or, in other words, the balloon would get smaller.

****

Pupil: I think it depends on the temperature.
_____ 27. Teacher: How could you go about testing your ideas?

****

_____ 28. Teacher: Tell us what happened in the demonstration.
Lynn: You rubbed the plastic sheet with the cloth and then those little bits of paper jumped up to it.

_____ 29. Teacher: Alright.

_____ 30. Teacher: What else?
Randy: Some of the paper seemed to be attracted to the cloth.

_____ 31. Teacher: Yes, good observing.

_____ 32. Teacher: Do you have any ideas about why the bits of paper were attracted to the plastic sheet?
Mary: Static electricity.

_____ 33. Teacher: Can you expand on your answer? I'm not sure I know what you mean.

****

_____ 34. Teacher: Now I'm going to do a demonstration.

_____ 35. Teacher: What do you predict will happen when I put the jar over the candle?
Pupil: The candle will go out.
Pupil: Will the jar melt?

****

APPENDIX B

HANDBOOK ON QUESTIONING AND USING PUPIL RESPONSES IN TEACHING SCIENCE

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Chapter I

INTRODUCTION

The Concept of Specific Teaching Behaviors

The emphasis on helping teachers develop a repertoire of specific teaching behaviors from which to choose in working with pupils is a relatively recent development in teacher education programs. The term "teaching behavior" refers here to a specific teacher action that is clearly definable and reliably observable and has a high likelihood of producing some specified type of pupil response. Examples are "asking observation questions" and "seeking clarification of pupil responses." In the teacher behavior approach to training teachers, teacher candidates learn to use the specific teaching behaviors through practice, feedback, and more practice in controlled teaching exercises. The goal of such an approach is to provide the new teacher with a wide range of teaching skills useful in a variety of instructional situations.

The Purpose of the Handbook

The purpose of this handbook is to help you develop specific teaching behaviors related to questioning and following through on pupil responses in teaching science. Five categories of teacher behaviors are emphasized. They are:

1.1 Asking observation and description questions.
1.2 Asking interpretation and explanation questions.
2.1 Acknowledging and reinforcing pupil responses.
2.2 Extending pupil ideas.
2.3 Probing pupil ideas.

These teacher behaviors are intended to be used in inquiry type lessons in which pupils actively investigate and seek solutions to problem situations. Fifty years ago the educational philosopher John Dewey (1966) was arguing for teaching approaches that involved the learners more directly with the learning task. Dewey emphasized that learning and thinking are private individual processes and that ideas can not really be conveyed intact from the teacher to the pupil. The teacher may be able to ask a question or make a statement that stimulates the

pupil to realize a problem for himself, but the pupil must be given time and opportunity to wrestle with the conditions of the problem, seeking and finding his own way out. A large part of the art of an inquiry teaching approach in science lies in making the difficulty of new problems large enough to challenge the existing yet incomplete concept of the pupils, but not so large that they can not begin almost immediately to modify their concepts to better fit the new experience.

The teacher can play a very important role in bringing about and nurturing conceptual growth through pupil inquiry. It is generally the teacher who establishes the topic for inquiry and sets the particular cognitive tasks (e.g., description, explanation, prediction) for pupils. The teacher can share in the pupils' inquiry by listening to and giving feedback on their ideas. The teacher can stimulate thinking by asking probing questions that require pupils to look in more depth at their initial ideas. At times the teacher may wish to clarify and add to vague ideas that pupils have offered. Occasionally the teacher may contribute facts and suggestions for pupils to use in their search. The teacher may eventually choose to provide the pupils with an accurate solution to the problem, but as a result of the inquiry process the solution can likely be built on the ideas and suggestions the pupils have already contributed.

There is no intention in the handbook to provide you with an exact recipe for mixing the five teacher behaviors in inquiry teaching, since there are, doubtless, many different ways to combine them successfully. The "right" teacher behavior for a given instructional situation depends on many factors which must be weighed during the course of a lesson, including teacher personality and knowledge variables, the nature of the lesson, and the personal factors of the pupils.

The Plan of the Handbook

Your goal in studying this handbook should be to develop competence in using the five teacher behaviors emphasized. Techniques for using these teacher behaviors are presented in Chapters Two and Three. Behavioral objectives for you are given in each of those chapters. You should be sure that you have achieved the stated objectives of Chapters Two and Three before beginning to study Chapter Four.

Chapter Four describes a set of procedures for you to follow in developing competence with these five teaching behaviors. The procedures follow a cycle of plan, teach, analyze, and evaluate. In achieving the objectives of this chapter, you will be expected to demonstrate your ability to use the five teaching behaviors in teaching inquiry lessons to small groups of pupils.

Objectives for Chapter I

After studying this chapter you should be able to:

1. discuss the meaning of the term "specific teaching behavior";

2. list the five categories of teaching behaviors emphasized in this handbook;

3. state the general purpose of this handbook.

Chapter II

DESCRIPTION AND EXPLANATION IN INQUIRY TEACHING

The inquiry teaching approach emphasized in this manual centers around specific teacher behaviors that are intended (1) to elicit the ideas of the pupils relative to selected problems and (2) to encourage pupils to look in more depth at their initial ideas. Through participating in the inquiry process the pupils can begin to develop readiness for understanding and giving explanations for problem events encountered in science lessons.

Establishing the Level of Thinking: Observation and Interpretation

Two primary tasks of science are to observe and describe the natural phenomena in the world of our experience and to arrive at interpretations or explanations for our observations (Jammer, 1957; Hempel, 1966). These tasks suggest two distinct levels of inquiry for pupils in the science classroom, a level of observation and a level of interpretation.

Observation. In elementary science, observation generally entails using one or more of the five senses to gather concrete information about a problem. The properties and actions or behaviors of the various objects involved in the problem may be noted. The concrete information gained through observation forms a base for higher levels of thinking.

Interpretation. Interpreting data is the correlate of describing objects and events. Observation is experiential, involving the student more or less directly with materials and events. Interpretation is conceptual, involving the student in reasoning about his experiences and in making up and testing his explanations for them (Karplus, 1972). Careful observation and description determine what is given. Interpreting data involves the ability to go beyond what is directly given to arrive at new and larger meanings of the data and at explanations for the various aspects of the problem situation. The explanation tends to make the situation intelligible or

comprehensible and gives the pupil a certain sense of intellectual satisfaction.

In interpreting data we seek to supply an answer to the "why" questions asked about the data of observation. There are various methods of answering why questions. One method is to deduce that the perplexing event is to be expected on the basis of known laws. A second method is to infer that the cause of a perplexing event is the same as the cause of another more familiar event. A third method may be to identify cause and effect relationships. Another method is to generalize that a common factor found in a limited series of events will be present in all such events. In each case we are seeking to go beyond the questions of observation and description to find the broader and more general meanings of our data.

It is important that elementary pupils spend considerable time at the observational level before beginning to search for problem explanations. This statement is supported by the research by Taba and Elzey (1964) on teacher behavior and thinking in elementary school children. Taba and Elzey (1964) found that unless teachers kept pupils from moving to higher levels of thinking before they had gathered an adequate supply of information at a concrete level, pupils were unable to sustain the higher levels of thinking.

Some specific types of questions for you to use in focusing pupil thought on a problem first at a level of observation and later at a level of interpretation are described in the following two sections. As you study these sections, refer to objectives 3, 4, 5, 6, and 7 of this chapter for your goals.

Teacher Behavior 1.1, Focusing on Observation and Description

The teacher usually sets the focus on observation and description through the questions he asks. The emphasis of questions in this category is on <u>what</u> took place rather than on <u>why</u> it took place.

The focusing questions the teacher uses should, in general, bo "open questions," i.e., questions that do not have just a single answer but can be answered in many ways. An open question such as "What are some of the things you noticed during the demonstration?" allows many pupils to contribute useful information for the inquiry process (Taba, 1967).

Some sample open questions that serve to focus attention on observing and describing are given below. These questions are intended to serve as guides for you in recognizing and formulating observation-description questions. Many of these questions have been adapted from a study by Koran (1970).

I. If you seek description of objects based on physical properties detectable by the senses or remembered from past experiences, ask such questions as:

a. "What did you see? hear? smell?"
b. "Would you describe the objects you used?"
c. "What are some things you noticed about the . . . in the demonstration?"

II. If you seek description of events and activities, ask such questions as:

a. "Would you describe what took place?"
b. "What did you do?"
c. "Tell us what happened in the experiment (activity, situation, investigation, demonstration)."
d. "What are some of the changes you noticed in the . . .?"
e. "What did you see that you liked (that startled you, that surprised you)?"

III. If you seek observations in terms of possible measurements, ask:

a. "How long is the object?"
b. "What is the temperature of the water?"
c. "Which bulb burned brightest?"
d. "Which one is heaviest?"

It is important for the teacher to maintain discussion on the same question until a considerable number of responses have accumulated (Taba, 1967). Such a strategy not only gives more students a chance to enter into the discussion, but also assures that all students will have available a variety of descriptive information from which to build explanations.

When getting responses from several students on the same question, it is generally not necessary for the teacher to repeat or rephrase the question. After one student has supplied an answer to a question, the teacher may redirect the question to another student by asking a question such as, "John, would you like to add anything else?" Once a pupil is familiar with your strategy of

redirecting questions, you should be able to get him to respond simply by calling his name or nodding in his direction.

Teacher Behavior 1.2, Focusing on Interpretation and Explanation

Interpretation and explanation require that the inquirer go beyond the descriptive information he has collected and offer tentative hypotheses, suggestions, inferences, and ideas about why an event took place. Interpretation can also involve the inquirer in seeking patterns and similarities and differences that relate various events.

When attempting to focus thought on interpreting and explaining, one good procedure is to start with the simpler problems that have been identified, gradually gather interpretations, and build toward the more difficult problems. Pupils may need considerable assistance at this point, especially in linking observation logically to principles or laws. Some sample questions that focus on interpretation and explanation follow.

I. If you seek ideas on patterns, similarities or differences, ask such questions as:

a. "How is this situation like (different from) the other one?"
b. "What similarities (differences) do you see in these situations?"
c. "Do you notice any pattern here?"

II. If you seek suggestions on scientific laws, principles, rules, theories, or concepts that might be involved, ask such questions as:

a. "What principles do you think may come into play here?"
b. "What rules (principles, laws, concepts) that we have learned do you think are needed in solving this problem?"
c. "How do you think such and such principle applies to this problem?"

III. If you seek ideas on the why or the possible cause of an event, ask questions such as:

a. "Why do you think so and so happened?"
b. "What ideas do you have on why this happened?"

c. "What hypotheses (suggestion, guesses, theories) do you have about the cause of this?"
d. "Can you explain why such and such happened?"
e. "What do you think is the cause of . . .?"
f. "Do you have any suggestions about why this took place?"

In asking questions that focus on interpretation and explanation, it is again important that the questions be "open" and that each question be pursued for a sufficient time to get responses from a considerable number of students. This strategy helps to assure that ideas and explanations at a variety of levels of abstraction are at hand for pupils of various levels of ability to consider.

Summary

The primary tasks of the scientist involve the description and the interpretation of natural phenomena. This suggests that inquiry in the classroom can be structured around observation-description and interpretation-explanation. Description requires that a pupil observe an object or event closely and communicate what he sees to others. Interpretation is the correlate of observation and description and involves going beyond the concrete information of experience to arrive at new and larger understandings of the experience and at explanations for the puzzling aspects of the problem event.

Recent research has demonstrated the necessity of teachers helping pupils to maintain thought at the concrete level of experience until an adequate supply of information on which to build higher levels of thinking has been gathered.

Question types for teachers to use in helping pupils focus thought at a level of observation-description and at a level of interpretation-explanation are given. The questions are largely "open" questions in that they can be answered in more than one way and allow several pupils to provide information and ideas on the question. The observation questions generally encourage a pupil to tell "what" he saw and to relate and organize the concrete information available to him. The interpretation questions encourage the pupil to find reasons for the puzzling aspects of the situation, to arrive at explanations for the observed events.

Objectives for Chapter II

You will have shown understanding of Chapter Two when you can:

1. discuss the nature and importance of the observation and description of problem situations by pupils in inquiry lessons;

2. discuss the nature and importance of the interpretation and explanation of problem events by pupils in inquiry lessons;

3. state the meaning of and give at least three examples of "open questions";

4. when given a list of questions, identify those which are open questions;

5. give at least five different examples of questions teachers can use to focus pupil thought on observing and describing a problem situation;

6. give at least five different examples of questions teachers can use to focus pupil thought on interpreting and explaining problem events;

7. when given a list of questions, identify those which are observation-description questions and those which are interpretation-explanation questions.

Chapter III

ACCEPTING AND USING PUPIL IDEAS

Research and Rationale

Educational research has not progressed to the point where the exact course of action for a given teacher in a particular situation can be prescribed. However, there are certain recurring themes in the research relating to the effects of teacher behavior on pupil outcomes which are suggestive for teachers. One of the most prevalent themes is that pupil growth appears to be influenced by the teacher's ability to involve pupils in the development and extension of ideas (Nuthall, 1970; Rosenshine and Furst, 1971).

Flanders (1970), a pioneer in the systematic observation of teaching and teacher behavior, identified four general ways in which teachers accept, develop, and extend pupil ideas. First, a teacher may merely repeat what a pupil has said or acknowledge the pupil's statement briefly in some way. Second, a teacher can attempt to clarify pupil ideas by paraphrasing them or introducing synonyms for unclear terms. Third, a teacher may use the ideas of pupils by comparing their observations, explanations, or points of view with his own or with those found in books or elsewhere. The teacher may also use the ideas of pupils in other ways, for example, in analyzing and solving a problem. Fourth, teachers may help pupils understand the consequences of their own ideas by using them as the basis for questions.

In an inquiry teaching sequence, the final explanation of the puzzling event does not necessarily have to be "discovered" by pupils. If they do make a discovery, fine. More than likely, however, pupils are not going to work out complete explanations on their own. Teachers should count on providing explanations at some point in the discussion and on following through to see how well each person comprehends the explanation. If the pupils have thought about and talked about the various ideas that go into the explanation and have had some opportunity to manipulate the materials involved, there is a greater likelihood that they will have

developed readiness for understanding the explanation. There is probably an optimum time for a teacher to give an explanation, but before the explanation is given, there should be extensive pupil discussion and teacher extension and probing of the ideas that are a part of the explanation.

It has been suggested that accepting and using the ideas of pupils is nothing more than what we would expect from a good conversation partner (McClellan, 1971). But the ability to focus on the thinking of others rather than on one's own thought processes does not seem to be prevalent either in ordinary conversation or in classroom teaching. In this chapter are presented some specific techniques for teachers to use in actively encouraging and following through on pupil thought.

Three categories of teacher behaviors related to responding to and using pupil ideas are defined and described in the following sections. The categories are:

2.1 Acknowledging and reinforcing pupil responses.
2.2 Extending pupil responses.
2.3 Probing pupil responses.

The organization of the categories is suggested by Flanders (1970). Some of the teacher behaviors within the categories are adapted from the work of Flanders (1970), McDonald and Allen (1967), Borg, et.al. (1970), and others. You should use behavioral objectives 2 through 5 of this chapter as a guide in studying the following sections.

Teacher Behavior 2.1, Acknowledging and Reinforcing Pupil Responses

The teacher should build into his behavior such an acceptance of error or mistake that a pupil feels he has the "right to be wrong" (ASCD Yearbook, 1962). The very process of inquiry involves the challenge of trying the unknown and necessarily must result in mistakes. The need to be always right, whether imposed by teachers, other pupils, or self is always a limiting, threatening position. Teachers have a major responsibility to help pupils explore new experiences and new meaning without penalizing or punishing the mistakes which are certain to accompany that process.

By "accepting" pupil ideas without initially judging or evaluating them, the teacher helps to establish a

climate in which pupils feel they can risk their ideas. Several accepting behaviors are presented below.

I. Teacher acknowledges pupil ideas. Here the teacher acknowledges pupil responses without evaluating them, being careful to leave the door open for further discussion. For example:

a. "O.K."
b. "Alright."
c. "That's one possibility."
d. "Let's list your idea on the board."
e. "Let's keep your idea in mind."

II. Teacher repeats pupil ideas. The teacher may accept a pupil idea by repeating it almost verbatim or paraphrasing the idea without changing it or adding to it significantly. Examples of repeating and paraphrasing are:

Pupil: "Maybe it's the air leaking."
Teacher: "O.K. You think it may be the air leaking." (repeating)
Or: "O.K. You think the bubbles may be caused by escaping air." (paraphrasing)

III. Teacher reinforces pupil ideas. A third type of accepting behavior is reinforcing pupil ideas. It is an established principle of psychology that a person's tendency to display an action is dependent on certain events that follow the action (Kagan, 1971). These special events are called "reinforcements." In order to encourage pupil participation in discussion a teacher may need to reinforce the act of responding. He may also wish to reinforce good thinking and good ideas.

One way of reinforcing pupil responses is with praise. For example:

a. "Good!"
b. "Fine!"
c. "Excellent!"
d. "I like your idea!"

A stronger way of reinforcing pupil responses is through praise followed by a word of explanation about the reason for the praise.

e. "Good! I like the way you are contributing."

f. "Your idea is very good because it relates a hypothesis to your observation."
g. "Fine! I like the way you compared your idea to Mary's idea."

Praise is important, but should not be given in such a way that the pupils think the idea praised is the only possible one. Other children might think the idea being praised is the correct one and thus give up on their own lines of thought. Reinforce the children for their efforts but let them know there is more to be done.

Kagan (1971) suggests that reinforcements will be more effective if they follow a schedule that is not predictable by the pupil. If the pupil is able to predict that the teacher will say "very good" after each and every response, this form of praise will tend to lose its reinforcement value for that situation. For best results, the teacher should vary the type and timing of reinforcements.

Reinforcement is, of course, more than a matter of what the teacher says. Research has shown that pupils are less inhibited about making responses and show more productivity and achievement when their teachers show warmth toward them, i.e., when their teachers tend to be approving, to provide emotional support, to express sympathetic attitudes, to accept their feelings, and so on (Gage, 1967).

Teacher Behavior 2.2, Extending Pupil Responses

When pupils give vague, incomplete, unorganized, or partially incorrect responses, or when pupils are on the right track but need assistance, the teacher may act to nurture and extend their ideas. Several techniques for extending pupil responses are described below.

I. Teacher clarifies pupil ideas. To help clarify a pupil idea, a teacher may restate the idea in simpler terms, reorganize the idea, or perhaps summarize it. For example, suppose a pupil has given an unclear and unorganized response. The teacher may reply:

a. "In other words, the air takes up more space when heated." Or,
b. "If I understand you correctly, you are saying that the air takes up more space when heated."

II. Teacher compares or contrasts two or more pupil ideas. When two or more pupils make suggestions that have significant similarities or differences, the teacher may wish to extend the ideas by comparing or contrasting them:

a. "Your idea is similar to Bill's in that . . ."
b. "Notice the difference in Sue's suggestion and John's suggestion. Sue said the rubber sheet would expand when the air was heated; John said it would expand when the air cooled."

III. Teacher corrects pupil responses. There is disagreement among teachers about how to handle incorrect ideas held by pupils. On the one hand, a pupil who is told that his idea is all wrong may be reluctant to participate in discussion again. On the other hand, in a goal directed inquiry session, incorrect ideas left unchallenged can cause confusion and interfere with correct explanations. Teachers need tactful ways of correcting or getting pupils to correct wrong notions. One possibility is to determine if part of the pupil's answer is correct and to reinforce this part (Borg, et.al., 1970). You might say, for example:

"Yes, heat does play a part in the expansion of the copper rod, but melting does not take place. Can you make another suggestion?"

Teachers can also help a pupil to examine the validity of his own answers. Techniques for doing this are discussed in connection with teacher behavior 2.3. Finally, it is important for the pupil to realize that in science the ultimate authority for the validity of an idea is not the teacher nor another person. Rather, to be considered correct, ideas must ultimately be consistent with observed evidence from the physical event involved.

IV. Teacher applies pupil ideas to problem solving. Applying an idea suggested by a pupil in problem solving or using the idea in building an explanation are good methods of extending pupil ideas. However, as the teacher brings more of his own ideas into the process, the teacher behavior shifts from "extending pupil ideas" to "teacher gives information or ideas."

V. Teacher summarizes or assesses group progress. Occasional summaries of the discussion and assessment of the various suggestions of the group members can also

serve to extend ideas and to contribute to the progress of the inquiry (Rosenshine and Furst, 1971).

Teacher Behavior 2.3, Probing Pupil Responses

After a pupil has contributed an idea to the discussion, the teacher may attempt to produce greater critical awareness by probing (McDonald and Allen, 1967). Probing is a strategy in which the teacher reacts to pupil statements by asking penetrating questions that require pupils to go beyond superficial, first-answer responses. A variety of probing techniques are outlined below.

I. Teacher seeks further clarification by the pupil. You may ask the pupil to clarify his response by giving more information or more meaning (McDonald and Allen, 1967). For example:

a. "What do you mean?"
b. "Could you put that in other words to make clearer what you mean?"
c. "Can you explain that further?"
d. "What do you mean by the term . . .?"
e. Teacher: "What is the relationship between pressure and volume?"
Pupil: "As the pressure goes up, the gas is condensed."
Teacher: "Can you tell us what is meant by condensed?", or "Can you restate that in terms of volume?"

II. Teacher seeks justification by the pupil. Here you are requiring the pupil to justify his response rationally (McDonald and Allen, 1967). You may say:

a. "What are you assuming here?"
b. "Why do you think that is so?"
c. "Have you oversimplified the problem . . . is there more to it?"
d. "Is this one or several questions?"
e. "I'm not sure I follow your reasoning. Tell us how you arrived at that answer."
f. "What is your evidence?"

III. Teacher seeks verification of hypotheses by pupils. Here you are calling upon the pupil to suggest means for verifying his hypothesis. For example, you may say:

a. "What would you do to test your hypothesis?"
b. "What would it take for that to be true?"
c. "What evidence (additional information, data) would we need to verify your hypothesis (suggestion, explanation)?"
d. "How could we test your idea?"

IV. Teacher asks a question based on pupil response. Here the teacher takes a pupil response and builds a question based on it. For example:

"You have said that the bubbles are caused by escaping air. What do you think happens to the air pressure in the tube when some of the air escapes?"

Summary

"Responding to and Using Pupil Ideas" represents a set of behaviors from which the teacher may draw in guiding pupils toward solutions of problems. A summary of this category of behaviors is given in Table 1.

The teacher behavior "acknowledging and reinforcing pupil responses" serves to give some recognition to pupils for their ideas and to encourage pupils to submit more suggestions.

Through the teacher behavior labeled "extending pupil responses" the teacher clarifies vague or unclear contributions by pupils, clears up misconceptions, adds useful information to the discussion, and gives direction to the discussion.

"Probing pupil responses" is the teacher behavior a teacher should select when he wishes to encourage pupils to look in depth at their own ideas.

Perhaps the greatest recognition and best reinforcement for a pupil comes when he sees his own idea singled out by the teacher and used in extension and probing.

TABLE 1

Summary of Teacher Behaviors for
Accepting and Using Pupil Ideas

2.1	Acknowledging and reinforcing pupil responses
	I. Teacher acknowledges pupil ideas
	II. Teacher repeats pupil responses
	III. Teacher reinforces pupil ideas
2.2	Extending pupil responses
	I. Teacher clarifies pupil ideas
	II. Teacher compares or contrasts pupil ideas
	III. Teacher corrects pupil responses
	IV. Teacher applies pupil ideas to problem solving
	V. Teacher summarizes or assesses group progress
2.3	Probing pupil responses
	I. Teacher seeks further clarification by the pupil
	II. Teacher seeks justification by the pupil
	III. Teacher seeks verification of hypotheses by pupils
	IV. Teacher asks a question based on pupil responses

Objectives for Chapter III

You will have shown understanding of Chapter Three when you can:

1. give an overall narrative description of what is meant by teacher "accepts and uses pupil ideas";

2. name and describe the three categories of teacher behaviors for accepting and using pupil ideas;

3. describe the differences between "extending pupil ideas" and "probing pupil ideas";

4. when given a summary outline of teacher behaviors for accepting and using pupil ideas, as in Table 1 in this chapter, give at least three examples of each subcategory (for instance, give at least three examples of the teacher behavior "teacher acknowledges pupil ideas");

5. when given a list of teacher statements and questions that might occur in inquiry lessons, identify those which are category 2.1 behaviors, acknowledging and reinforcing pupil responses, those which are category 2.2 behaviors, extending pupil responses, and those which are category 2.3 behaviors, probing pupil responses.

Chapter IV

DEVELOPING INQUIRY TEACHING SKILLS

Developing competence in conducting inquiry discussion sessions is a matter of planning, practice, analysis and evaluation, and more practice. This chapter provides some procedures for you to follow in learning to use the specific teacher behaviors introduced in Chapters Two and Three. The procedures center around a lesson planned by you and taught to a small group of pupils in a short time period.

Planning

First, prepare a lesson plan for teaching an inquiry lesson to a small group of pupils. The lesson should contain clear statements of the objectives which you intend for the pupils to attain. Corresponding to each objective should be one or more lesson activities designed to result in pupil attainment of the objectives. Make sure that you yourself have a good basic understanding of each problem for inquiry and its explanation.

Practice

Next, teach the lesson to a small group of pupils in a controlled laboratory type situation. Use an audio tape recorder to record the lesson. Place the microphone in such a position that what you say and what the pupils say will be recorded. Remember that your role is to focus pupil attention on a problem situation, to ask questions that direct thought to observation and interpretation, and, generally, to serve as a catalyst in encouraging the exploration and inquiry of the pupils. Listen carefully to what the pupils say; be satisfied only rarely with one word responses. Where appropriate, extend the pupil ideas yourself or probe for deeper responses using the techniques suggested in Chapter Three. Try to use each of the five specific behaviors several times during the lesson.

Analysis

A system of categories developed from the teacher behaviors defined in Chapters Two and Three serves as a framework for describing and analyzing your inquiry lesson. In brief, an observer listens to a tape recording of a lesson, generally his own, and counts the number of occurrences of each behavior defined in the category system. The intent is to obtain objective data on the frequency of the teacher's use of each of the defined teacher behaviors. The teacher may then use this data as the basis for evaluating and modifying his own teaching behavior. The system of categories for coding teacher behaviors and the specific analysis and evaluation questions which accompany it will be referred to as the Inquiry Teaching Analysis System (ITAS).

The ITAS is based on some of the suggestions of Ned Flanders (1970) and Hilda Taba (1966). The coding system in the ITAS contains five categories for coding or tallying teacher questions and statements in an inquiry lesson. Table 2 lists and describes the five categories. To code a lesson, listen to the tape recording of the lesson and tally the occurrence of each identifiable "behavioral event" on the special coding form (Figure 1). A behavioral event is defined as the smallest bit of behavior that can be assigned to a category. A behavioral event may be a single word, such as "Good!" or "O.K." which would be assigned to category 2.1, acknowledging and reinforcing pupil responses. It may be a sentence fragment or a complete sentence, such as a question focusing on observation (category 1.1). Or it may be a complete paragraph, such as when a teacher summarizes and assesses pupil progress (category 2.2).

Ground rules for coding. Because of some of the problems involved in identifying and coding behavioral events, certain ground rules need to be established. These rules can aid in developing consistency among observers in categorizing teacher behaviors. Before beginning to code a lesson, you should study these ground rules carefully.

Rule No. 1: A question is any teacher statement designed to elicit a response from the pupil. Thus, some declarative statements, such as, "Tell me what you saw," are considered to be questions.

Rule No. 2: Questions that do not actually call for pupil responses but are used to give information, to acknowledge pupil ideas, to clarify pupil ideas, or for

TABLE 2

Summary of
Categories of Inquiry Teaching Behaviors

ESTABLISHING LEVEL OF THOUGHT	1.1 TEACHER ASKS OBSERVATION AND DESCRIPTION QUESTIONS: Teacher questions designed to focus thought at a level of observation. Includes questions asking for description of objects and description of events. Emphasis is on what took place. Factual recall questions are not coded in this category. 1.2 TEACHER ASKS INTERPRETATION AND EXPLANATION QUESTIONS: Teacher questions requiring the pupil to offer tentative hypotheses, suggestions, inferences, or ideas about the reasons why an event took place; also, questions that seek patterns, relations, similarities, and differences are included.
RESPONDING TO AND USING PUPIL IDEAS	2.1 TEACHER ACKNOWLEDGES AND REINFORCES PUPIL RESPONSES: Teacher acknowledges, repeats or paraphrases, or reinforces a pupil response. 2.2 TEACHER EXTENDS PUPIL RESPONSES: The teacher extends a pupil idea by clarifying it, by comparing or contrasting it with another idea, by correcting the idea when partially or totally incorrect, and by applying the idea to problem solving; summarizing or assessing group progress is also included. As the teacher adds and uses more of his own ideas, shift from this category as he is no longer extending the ideas of pupils. 2.3 TEACHER PROBES PUPIL RESPONSES: Teacher questions asking pupils to follow through on their own ideas, includes seeking clarification or justification of ideas by the pupils; seeking verification of pupil hypotheses; and building a question based on the idea of a pupil. Code a question in this category only if it is used by the teacher to follow up on ideas expressed by pupils.

some other purpose, should not be coded as a question (categories 1.1, 1.2, or 2.3).

Rule No. 3: In coding an event, the observer should not be overly concerned with his own biases or with the teacher's intent. Rather, he should ask, "What does this behavior mean to the pupils?"

Rule No. 4: Questions that call for the simple recall of remembered facts or other previously learned information should not be coded as observation questions. Examples of recall questions that should not be coded are:

"Have you studied this before?"
"What did we do yesterday?"
"What is air pressure?"

Rule No. 5: Interpretation questions and probing questions are often confused. Probing questions always relate to an idea already expressed by a pupil. If the question does not proceed in some way from a pupil idea, it should not be classified as a probing question (category 2.3).

Rule No. 6: Interpretation questions are based on teacher ideas and are used to lift thought from a level of observation to reasoning about the observation or to shift thought from interpreting one problem aspect to interpreting another.

Rule No. 7: When such words as "O.K.," "fine," or "good" are overused, they may have little positive effect on pupils. If you judge that the use of such words is not having a reinforcing or encouraging effect on pupils, do not code them.

Evaluation

The tallying of teacher behaviors on the coding form gives objective data about teaching performance. The objective data can then be used as a partial basis for making subjective judgments about the quality of the use of the teaching behaviors. In the Inquiry Teaching Analysis System, self-evaluations of performance is made through a teacher candidate's responding to a series of questions about his or her use of the teaching behaviors.

Questions to consider in evaluating inquiry teaching. Some questions for you to consider in examining and evaluating your teaching behavior during a lesson are given in this section. In answering the questions be as specific

as you can; specify what occurrences in the lesson serve as evidence supporting your answer. In evaluating a lesson it is well for you to remember that you are ultimately the best judge about what teaching behavior is desirable or undesirable for you. You must determine through your own analyzed experience what constitutes effective teaching for you.

Question 1: Did I pose the problem effectively?

Did the problem presentation have a dramatic effect upon the pupils? Were pupils anxious to find out the cause of the event?

Question 2: How effective were my observation and description questions?

How many observation questions (category 2.1) did you use? The effectiveness of focusing questions is not necessarily determined by the number you used, nor by the way they are worded, but by the ways pupils respond to them. Did students respond to your observation and description questions by giving statements about what they saw taking place? How many of the pupils responded with description statements? How long was discussion maintained on the description level? Was sufficient information on the description level gathered before you lifted thought to a level of interpretation?

Question 3: How effective were my interpretation and explanation questions?

How many interpretation questions did you ask? Did the pupils respond with inferences and explanations? How long were you able to maintain discussion at a level of interpretation and explanation?

Question 4: To what extent am I accepting of pupil ideas?

How often did you repeat, paraphrase, or reinforce pupil ideas (category 2.1)? Although the total amount of accepting behavior you used is important, the ways you accept and support pupil ideas are more important. Is there evidence that your accepting statements and attitude had an encouraging effect upon pupils? Did you overuse any accepting words, such as "Fine!," "Alright," "O.K.," or "Very good!"?

Question 5: How effectively did I extend pupil ideas?

How many instances of extending pupil ideas (category 2.2) did you record? The extension of pupil ideas is, perhaps, the most important teacher behavior in inquiry sessions. Note the ways you clarified pupil ideas. Did you compare one pupil idea with another? How did you correct incorrect responses? How and when did you summarize group progress? Is there evidence that your extension of pupil ideas resulted in better pupil achievement of learning goals? Were there times when you should have extended pupil ideas and did not?

Question 6: Did I probe student responses effectively and often enough?

How many instances of probing pupil ideas (category 2.3) did you record? How did the pupils respond to your probes? Did your probes result in students giving deeper and more complete responses? Did you probe when you might better have clarified the idea yourself? Did you overlook opportunities to probe?

Question 7: Was there adequate pupil participation in the lesson?

Consider not only the relative amount of pupil talk, but also the distribution, extent, and quality of pupil talk. Note how many of the pupils entered into the discussion, whether or not the pupil talk was brief or sustained, the ways in which pupil talk was influenced by your behavior, and whether or not pupil talk was generally related to the lesson.

Question 8: What specific teacher behaviors do I wish to concentrate on and improve?

Summary

A sequence of planning, practice, analysis, evaluation, and more practice can help teachers develop competence in using inquiry teaching skills. First, the teacher should plan a lesson for teaching to a small group of school pupils. Second, the lesson should be taught to the pupils in a controlled teaching atmosphere. The lesson should be recorded on audio tape. Third, the audio-taped lesson is analyzed to determine the frequency of teacher use of five specific teacher behaviors described in Table 2. The five behaviors are:

1.1 Asking observation and description questions.
1.2 Asking interpretation and explanation questions.
2.1 Acknowledging and reinforcing pupil responses.
2.2 Extending pupil responses.
2.3 Probing pupil responses.

Fourth, a series of questions relating to the teacher's effectiveness in using the five behaviors is answered by the teacher. Finally, steps two through five are repeated with the teacher paying special attention in the reteaching to those behaviors which he thinks need improving. A summary outline of the procedures suggested for developing competence in using the five specific teacher behaviors is shown in Figure 2.

FIGURE 1

Inquiry Teaching Coding Form

NAME OF TEACHER	DATE OF TEACHING
LESSON	GRADE LEVEL

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TOTAL
FOCUSING QUESTIONS	1.1 Observing																				
	1.2 Interpreting																				
RESPONDING TO PUPIL IDEAS	2.1 Acknowledging or reinforcing																				
	2.2 Extending																				
	2.3 Probing																				

FIGURE 2

Summary of Procedures in Developing Inquiry Skills

1. Learn the Teaching Behaviors

Master the five teaching behaviors of Chapter Two and Three at a knowledge level.

2. Plan a Lesson

Prepare a lesson plan for presenting an inquiry lesson to a small group of pupils.

3. Teach the Lesson

Teach the lesson to a small group of pupils. As you teach the lesson, use the five teacher behaviors. Tape record the lesson.

4. Learn the Coding System

Master the coding system of Table 1 and the ground rules for coding.

5. Tally

Tally the occurrences of each teacher behavior in a 15-minute portion of your lesson. The tally will be more reliable if another individual helps you code the lesson.

6. Answer Special Questions

Answer the "Questions to consider in evaluating inquiry teaching." Use the objective data obtained in coding the lesson as a basis for your answers.

7. Discuss Performance

Talk with your instructor about your performance and ways to improve your performance.

8. Reteach

Teach the lesson again, concentrating on making needed improvements in your use of the teacher behaviors.

9. Analyze and Re-Evaluate

Analyze and evaluate your second lesson as needed.

Objectives for Chapter IV

You will have achieved the knowledge level objectives of Chapter Four when you can:

1. give a narrative description of the steps to take in developing specific inquiry teaching skills;

2. list and describe the five categories of inquiry teaching behaviors (Table 2);

3. describe the procedures for coding a lesson using the Inquiry Teaching Coding Form (Figure 1) and the seven ground rules for coding.

You will have achieved the performance level objectives of this chapter when you can

*4. code a taped inquiry lesson taught by you or another person, getting at least 60%-70% agreement with another coder on the assignment of behavioral events to specific categories;

*5. teach a 15-minute inquiry lesson using each of the five defined teaching behaviors at least six times with at least three of the uses of the behavior in each category being clearly of high quality relative to wording, timing, and effect on pupils as judged by an outside observer.

*The minimum percentage of agreement in objective 4 and the minimum number of total occurrences and high quality occurrences given in objective 5 represent reasonable expectations of pre-service teachers as judged from the analysis of data collected in the field testing of this handbook. Your course instructor may wish to establish different performance standards for these objectives.